

The opinion in support of the decision being entered today
is *not* binding precedent of the Board

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte IRENE T. SPITSBERG

Appeal 2007-0060
Application 09/524,227
Technology Center 1700

Decided: September 28, 2007

Before EDWARD C. KIMLIN, CHARLES F. WARREN, and
JEFFREY T. SMITH, *Administrative Patent Judges*.

WARREN, *Administrative Patent Judge*.

DECISION ON APPEAL

Applicant appeals to the Board from the decision of the Primary Examiner finally rejecting claims 1 through 20 in the Office Action mailed May 26, 2005 (Office Action). 35 U.S.C. §§ 6 and 134(a) (2002); 37 C.F.R. § 41.31(a) (2005).

We affirm the decision of the Primary Examiner.

Claim 1 illustrates Appellant's invention of a method of improving the thermal fatigue life of a thermal barrier coating, and is representative of the claims on appeal:

1. A method of improving the thermal fatigue life of a thermal barrier coating by modifying the grain structure of a diffusion aluminide bond coat that adheres the thermal barrier coating to a surface of a superalloy component, the method comprising the steps of:

depositing the aluminide bond coat on the component so as to be characterized by substantially columnar grains that extend substantially through that portion of the aluminide bond coat overlaying the surface of the component, the grains having grain boundaries exposed at the surface of the aluminide bond coat, the surface of the aluminide bond coat having surface irregularities as a result of grain boundary ridges defined by the grain boundaries at the surface of the aluminide bond coat; and then

recrystallizing at least a surface region of the aluminide bond coat during or prior to depositing the thermal barrier coating on the surface of the aluminide bond coat, wherein new grains form at the surface of the aluminide bond coat and a ceramic layer is deposited on the surface of the aluminide bond coat to form the thermal barrier coating;

wherein following the recrystallizing step, the new grains cause the surface of the aluminide bond coat to be smoother and flatter as a result of eliminating at least some of the grain boundary ridges, whereby the ceramic layer is deposited on the smoother and flatter surface of the aluminide bond coat.

The Examiner relies upon the evidence in these references¹:

Duhl US 4,512,817 Apr. 23, 1985

¹ We have not considered US 5,413,871 discussed by the Examiner at Answer 27, to support the grounds of rejection because the reference is not relied on in any ground of rejection, and accordingly, reliance thereon in this manner is inappropriate. *See In re Hoch*, 428 F.2d 1341, 1342 n. 3, 166 USPQ 406, 407 n.3 (CCPA 1970); *cf. Ex parte Raske*, 28 USPQ2d 1304, 1304-05 (Bd. Pat. App. & Int. 1993).

Appeal 2007-0060
Application 09/524,227

Loersch	US 4,514,469	Apr. 30, 1985
Nakamura ²	JP 1-180959 A	Jul. 18, 1989
Duderstadt	US 5,238,752	Aug. 24, 1983
Hayess	US 6,210,744 B1	Apr. 3, 2001

Appellant requests review of the following grounds of rejection under 35 U.S.C. § 103(a) advanced on appeal (Br. 18):

claims 1, 4 through 8, and 10 as unpatentable over knowledge in the prior art acknowledged by Appellant (APA)³ in view of Nakamura (Answer 3);
claims 2, 11, 13 through 18, and 20 as unpatentable over the APA in view of Nakamura, further in view of Loersch (*id.* 8);
claim 3 as unpatentable over the APA in view of Nakamura, further in view of Duhl (*id.* 16);
claim 9 as unpatentable over the APA in view of Nakamura, further in view of Hayess (*id.* 18);
claim 12 as unpatentable over the APA in view of Nakamura, further in view of Loersch, and further in view of Duhl (*id.* 19); and
claim 19 as unpatentable over the APA in view of Nakamura, further in view of Loersch, and further in view of Duderstadt (*id.* 20).

Appellant argues the claims in each of the first two ground of rejection as a group. Br. 27 and 34. Appellant's arguments are principally directed to the combination of the APA and Nakamura with respect to claim 1, which is the principal combination in each ground of rejection. Br. 27-33, 34, 36, 37, 38, and 40. Thus, we decide this appeal based on claim 1 as

² We refer to the translation of Nakamura prepared for the USPTO by Schreiber Translations, Inc. (PTO 2006-3781 April 2006). We further refer as indicated to an Abstract of Nakamura prepared by the Japanese Patent Office (1989) (JPO Abstract).

³ The APA is the Background of the Invention section at Specification 1:8 to 4:15, and the acknowledged thermal barrier coating (TBC) system and associated methods at Specification 8:8 to 10:24, which disclosure refers to Specification Figs. 1-5. Answer, e.g., 3; Br., e.g., 20.

representative of the grounds of rejection. 37 C.F.R. § 41.37(c)(1)(vii) (2005).

The principal issue in this appeal is whether the Examiner has established a *prima facie* case of obviousness over the combination of the APA and Nakamura. Thus, a discussion of Loersch, Duhl, Hayess, and Duderstadt is not necessary to our decision.

The plain language of claim 1 specifies a method comprising at least the steps of, with reference to Figs. 2 and 6, (1) depositing any aluminide bond coat 24 on any superalloy component 22, the bond coat having substantially columnar grains 32 that extend substantially through the portion of the bond coat such that grain boundaries 34 are exposed at the surface of the coat and define grain boundary ridges resulting in bond coat surface irregularities; and (2) recrystallizing at least a surface region of aluminide bond coat 24 during or prior to the deposition of any thermal barrier coating 26 on aluminide bond coat 24, wherein new grains 42 are formed at the surface of bond coat 24 and a ceramic thermal barrier coating 26 is deposited on that bond coat surface. Specification, e.g., 8:8 to 10:7 and 11:33 to 12:30. The recrystallization step can be induced by peening aluminide bond coat 24 and heating the peened bond coat. See, e.g., claim 2. Claim 1 further specifies the recrystallizing step results in new grains 42 in the aluminide bond coat which provide a smoother and flatter surface as a result of eliminating at least some of the grain boundary ridges, and the ceramic layer 26 is deposited on the smoother and flatter surface. The transitional term “comprising” opens the claim to include any additional materials, steps and conditions. *See, e.g., In re Baxter*, 656 F.2d 679,

686-87, 210 USPQ 795, 802-03 (CCPA 1981) (“As long as one of the monomers in the reaction is propylene, any other monomer may be present, because the term ‘comprises’ permits the *inclusion* of other steps, elements, or materials.”).

The recrystallization step in claim 1 must result in “a smoother and flatter” aluminide bond coat surface at least to the extent that “at least some of the grain boundary ridges” are eliminated.

There is no dispute with the Examiner’s findings that the APA describes a prior art method wherein an aluminide bond coat is formed by a method step falling within the first method step of the claimed method encompassed by claim 1, wherein the prepared bond coat has an irregular surface on which a ceramic thermal barrier coat is deposited in a second step. The bond coat produced by the APA process “is characterized by substantially columnar grains and grain boundaries exposed at the bond coat surface,” and does not teach recrystallization of the bond coat prior to or during depositing a TBC. Answer, e.g., 3 and 22-23; Br. 20. The difference between the APA process and claim 1 thus resides in the second step and the result of that recrystallization. Answer 3.

There is also no dispute with the Examiner’s findings that Nakamura would have described deposition of an aluminide coating layer as the outer layer on the surface of a superalloy component, after which the coat layer is peened and then heated to recrystallize the surface, resulting in new fine grains on the surface; and that the recrystallization process results in a diffusion aluminide coating layer with “an improved thermal fatigue resistance without deteriorating the corrosion resistance,” “a low crack

propagation speed due to the small grain size of the recrystallized grains,” and “an increased resistant to the coating layer peeling-off.” Answer 3-4 and 23, citing the JPO Abstract; Br. 22. There is no dispute that Nakamura’s recrystallization step corresponds to the second step of the process encompassed by claim 1, and that the reference does not teach or suggest the recrystallized coating “could be acceptable as a bond coat for a TBC.” Br. 22; Answer 3-4.

The Examiner determines

it would have been obvious to one of ordinary skill in the art to improve the fatigue life of the TBC system of the [APA] by modifying the grain structure of the aluminide bond coat by recrystallizing at least a surface region of the aluminide bond coat during or prior to depositing the TBC on the surface of the bond coat, wherein new grains form at the surface of the bond coat, as taught by [Nakamura], with the reasonable expectation of successfully and advantageously providing the coated superalloy component/blade of the [APA] with the following benefits: (1) an improved thermal resistance, (2) a lower crack propagation speed, and (3) an increased resistance to the peeling-off of the coating layer (i.e., the TBC system).

Answer 4.

There is also no dispute that if the APA and Nakamura can be combined, the resulting method would fall within the claimed methods encompassed by claim 1. Answer 23; Br. 22.

The issue, as stated by Appellant, is “whether the recrystallization (and inherently smoothing) effect sought by Nakamura for a diffusion coating used as an outer (non-bond coat) coating can be properly combined with the [APA], even though the [APA] expressly teaches away from smoothing a diffusion coating used as a bond coat for a TBC.” Reply Br. 9.

Appellant contends, with respect to diffusion aluminide bond coats, that the APA “teaches away from any process (such as polishing or peening) that would result in smoothing and flattening the surface of” bond coat 24 “because the result would be reduced adhesion of the TBC (26) and reduced crack resistance of the alumina scale-bond coat interface, thus promoting the spallation of the TBC (26).” Br. 21 (emphasis omitted). Appellant relies on the following part of the APA:

TBC spallation initiates by a different mechanism on diffusion aluminide bond coats, and primarily along the alumina-bond coat interface. Accordingly, the toughness of the alumina and the alumina-bond coat interface are most important to TBC deposited on a diffusion aluminide bond coat. From this perspective, polishing a diffusion aluminide bond coat would be expected to reduce TBC life, since sufficient surface roughness of the bond coat would be desired to promote adhesion of the alumina to the bond coat, and to inhibit crack propagation through the alumina and alumina-bond coat interface. As a result, conventional practice has been to grit blast the surface of a diffusion aluminide bond coat to increase its roughness to about 50 microinches (about 1.25 micrometers) Ra or more before depositing the TBC.

Specification 3:34 to 4:15; see Br. 21.

Appellant contends the testimony in the Spitsberg Declaration⁴ explains the difference between the coat failure mechanism addressed by Nakamura’s method and the TBC spallation failure mechanism that Dr. Spitsberg and others in the TBC art address, and why those in the art would not view the improvements in the diffusion aluminide coat layer obtained by

⁴ Dr. Spitsberg’s Declaration under 37 C.F.R. § 1.132 was filed February 22, 2005.

Nakamura's method as related to TBC spallation in diffusion bond coat-based TBC systems such as in the APA. Br. 28-29.

Appellant does not specify the parts of the Spitsberg Declaration supporting the position. It seems to us that at least the following testimony of Dr. Spitsberg pertains to Appellant's statements:

(7) Nakamura is applied by the Examiner as disclosing that thermal fatigue causes cracks to form in and propagate through a diffusion aluminide coating, which results in failure of the coating by "peeling." I am not aware of anything in the technical literature which supports Nakamura's theory that diffusion coatings fail as a result of cracks propagating through the coating (i.e., in the plane of the coating). Instead, myself and others in the technical community have observed failure of a diffusion coating as the result of rapid oxidation of the diffusion zone beneath the coating, and that rapid oxidation is the result of oxidizing agents penetrating grain boundary cracks initiated at and promoted by the columnar grain boundaries of the diffusion coating. While I and others have attributed cracking of diffusion coatings on field-returned airfoils to thermal or mechanical fatigue, these cracks are observed to form along the columnar grain boundaries of the coatings (i.e., vertical (normal) to the substrate surface), and therefore do not result in peeling of the diffusion coating. These vertical cracks opened paths for oxidizing agents, resulting in oxidation and cracking of the diffusion zone beneath the diffusion coating. . . .

(8) Aside from my debate over failure mechanisms in diffusion coatings, I believe it is now generally accepted in the technical community that spallation of a TBC system employing a diffusion coating as a bond coat (i.e., a diffusion bond coat) is related to cracking of the alumina scale that forms on the surface of the diffusion bond coat . . . Therefore, TBC spallation involves a failure mechanism that takes place above the diffusion bond coat, and not within the diffusion bond coat itself. . . .

(9) . . . I believe there is ample evidence to argue that the problems described by Nakamura as being associated with diffusion aluminide coatings do not exist in the [APA's] TBC system. I and other experts in this field have observed and concluded that deformation of the diffusion bond coat causes horizontal cracking of the TBC and/or alumina scale, both of which are above the bond coat. Because bond coat cracking does not play a role in spallation of TBC deposited on a diffusion bond coat, I and others concerned with TBC spallation would not consider Nakamura's peening and recrystallization process to be relevant or useful.

. . . .

(10) . . . [T]he technical community that has studied TBC spallation would not consider Nakamura's recrystallization process, since the benefits of Nakamura's process are intended to address problems that are not observed in TBC systems. Instead of concern for thermally-induced horizontal cracking of diffusion coatings (as is Nakamura), or concern for vertical cracking and oxidation of diffusion coatings (as are others that have studied non-TBC diffusion coating failures), the concern of those that have studied TBC system spallation is the horizontal cracking of the TBC and alumina scale that lie above a diffusion bond coat.

Spitsberg Declaration 3-7 (emphasis omitted).

The Examiner contends the APA at Specification 4:1-15 indicates recrystallization would be expected to result in the disadvantages of reduced TBC life and reduce crack propagation inhibition, and not that recrystallization could not be performed. Answer 23-24. The Examiner contends that the advantages taught for the product of Nakamura's method would have provided motivation to combine that recrystallization method with the APA process. The Examiner finds Nakamura's process results in fine recrystallization grains on the surface of the aluminide coating layer

that increase the yield strength of the coating layer, providing good resistance to thermal fatigue without loss in resistance to corrosion, and that the APA teaches the service life of a TBC system is limited by spallation caused by thermal fatigue. Answer 26, citing Nakamura 7-8, and Specification 2:30-32. The Examiner concludes that one of ordinary skill in the art with knowledge of thermal fatigues thus would use Nakamura's process to address the thermal fatigue problem. Answer 26. The Examiner refers to the findings with respect to the Spitsberg Declaration set forth in the Office Action at 6-9. Answer 27. The Examiner contends that even if the facts and opinion in the Spitsberg Declaration establish a different failure mechanism were correct, one of ordinary skill would have been motivated to use Nakamura's recrystallization step for the advantages for the diffusion aluminide coating layer taught by the reference, regardless of whether the diffusion aluminide coating layer is the "ultimate cause of TBC failure/spallations." Answer 27.

Appellant contends that smoothness of the bond coat layer and the recrystallization step are required by the claims, but the "effect of smoothing a diffusion bond coat is a key claimed aspect," and the APA teaches away from this aspect. Reply Br. 4-5 (emphasis omitted). In this respect, Appellant contends the APA teaches away in the disclosure that "conventional practice has been to grit blast the surface of a diffusion aluminide bond coat to increase its roughness to about 50 microinches (about 1.25 micrometers) Ra or more before depositing the TBC." Specification 4:11-15; Reply Br. 6-7.

We find Nakamura would have disclosed to one of ordinary skill in this art that it was known in the prior art to coat superalloys used in gas turbine components to improve resistance to thermal stress and high temperature corrosion. Nakamura 4. The aluminide diffusion coating has crystal grains which are “large” and “cracks due to thermal stress . . . form in the surface of the coating.” *Id.* “When the cracks increase in size, holes form, corrosive gas enters, and the base material corrodes.” The problem addressed by Nakamura is that conventional coating layers develop cracks at high levels of thermal stress that “generally develop along the boundaries of the [large] grains,” and when the cracks reach “the base material, corrosive gas reacts” with that material, corroding the material and extending the cracks. *Id.* 5. Nakamura discloses a method forming “fine crystal grains in the vicinity of the surface of the coating layer” which “are known to have high yield strength, enhancing the resistance to thermal fatigue” without loss in resistance to corrosion.” *Id.* 5-7. “The generation of cracks can be stopped by forming fine recrystallized grains in the coating layer.” *Id.* 6.

We find “FIG. 5 (prior art)” is described as showing “a crack 40 eventually formed in the scale 36 and typically propagated into the bond coat/oxide interface,” and indeed, illustrates crack 40 extending off the surface of diffusion aluminide coating grain 32. Specification 11:13-15 and Fig. 5.

We determine the combined teachings of the APA and Nakamura, the scope of which we determined and discussed above, provide convincing evidence supporting the Examiner’s case that the claimed invention

encompassed by claim 1, as we interpreted this claim above, would have been *prima facie* obviousness to one of ordinary skill in the TBC arts familiar with methods of forming diffusion aluminide coating layers on superalloy components to obtain thermal fatigue resistant properties in the coatings. On this record, we agree with the Examiner that one of ordinary skill in this art armed with the knowledge in the art of methods of forming TBC systems admitted by Appellant would have combined this knowledge with the teachings of Nakamura and would have been led thereby to use Nakamura's recrystallization step for diffusion aluminide coatings in the known methods of producing a TBC in the reasonable expectation of obtaining the thermal fatigue resistance properties for the diffusion aluminide bond coat taught by Nakamura. Thus, this person would have reasonably arrived at the claimed methods encompassed by claim 1 without recourse to Appellant's Specification. *See, e.g., KSR Int'l Co. v. Teleflex, Inc.*, 127 S. Ct. 1727, 1741, 82 USPQ2d 1385, 1389 (2007) (analysis supporting obviousness should "identify a reason that would have prompted a person of ordinary skill in the art to combine the elements" in the manner claimed); *In re Kahn*, 441 F.3d 977, 985-88, 78 USPQ2d 1329, 1334-37 (Fed. Cir. 2006); *In re Young*, 927 F.2d 588, 591-92, 18 USPQ2d 1089, 1091-92 (Fed. Cir. 1991); *In re Dow Chem. Co.*, 837 F.2d 469, 473, 5 USPQ2d 1529, 1531 (Fed. Cir. 1988);⁵ *In re Keller*, 642 F.2d 413, 425,

⁵ The consistent criterion for determination of obviousness is whether the prior art would have suggested to one of ordinary skill in the art that [the claimed process] should be carried out and would have a reasonable likelihood of success viewed in light of the prior art. [Citations omitted] Both the suggestion

208 USPQ 871, 881 (CCPA 1981);⁶ *see also In re O'Farrell*, 853 F.2d 894, 903-04, 7 USPQ2d 1673, 1680-81 (Fed. Cir. 1988) (“Obviousness does not require absolute predictability of success. . . . For obviousness under § 103, all that is required is a reasonable expectation of success.” (citations omitted)).

Appellant’s contentions do not successfully rebut the *prima facie* case. We cannot agree with Appellant that the passage from the APA relied on establishes knowledge in the art leading away from employing Nakamura’s recrystallization step in any prior art method of forming any TBC on any diffusion aluminide bond coat. The expectation of reduced TBC life from polishing or smoothing the surface of a diffusion aluminide bond coat is based on a “desired” surface roughness “to promote adhesion” and “to inhibit crack propagation through the alumina and alumina-bond coat interface.” The “desire” for a certain roughness leads to the “conventional practice . . . to grit blast the surface of a diffusion aluminide bond coat to increase its roughness.”

and the expectation of success must be founded in the prior art, not in the applicant’s disclosure.

Dow Chem., 837 F.2d at 473, 5 USPQ2d at 1531.

⁶ The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference; nor is it that the claimed invention must be expressly suggested in any one or all of the references. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art.

Keller, 642 F.2d at 425, 208 USPQ at 881.

We find from this information and from Specification Fig. 5 that reduced adhesion between the diffusion aluminide bond coat and the thermal barrier coat can result in crack propagation through the alumina-bond coat interface, and thus the crack would be on the surface of the diffusion aluminide bond coat. A crack can form in the thus exposed diffusion aluminide bond coat and propagate through the bond coat, contributing to TBC system failure at least to that extent. We further find no information in the APA which discredits Nakamura's recrystallization step, *see, e.g.*, *Young*, 927 F.2d at 591-92, 18 USPQ2d at 1091-92, or which would have suggested that one of ordinary skill in this art would have known such step cannot be used in any method of forming any TBC system. *See, e.g.*, *In re Gurley*, 27 F.3d 551, 552-53, 31 USPQ2d 1130, 1131-32 (Fed. Cir. 1994). Indeed, the "desire" expressed in the observation of the prior art in the APA is based on a desire to optimize adhesion between the diffusion aluminide bond coat and the thermal barrier layer for TBC systems for components used in the highest temperature regions (Specification, *e.g.*, 1:23-27), and there is no disclosure that this "desire" holds for all methods of forming any TBC system encompassed by claim 1 or disclosed in the prior art. Thus, one of ordinary skill in this art would have been motivated to use Nakamura's recrystallization step in forming a diffusion aluminide coating layer to obtain the advantages of thermal fatigue resistance and crack propagation in this layer in forming TBC systems where the imparted advantages extend the service life of the coated component. *See, e.g.*, *Gurley*, 27 F.3d at 553, 31 USPQ2d at 1132 ("We share Gurley's view that a person seeking to improve the art of flexible circuit boards, on learning

from Yamaguchi that epoxy was inferior to polyester-imide resins, might well be led to search beyond epoxy for improved products. However, Yamaguchi also teaches that epoxy is usable and has been used for Gurley's purpose.""). Indeed, this person would have used a superalloy component coated with a diffusion aluminide coating layer prepared by Nakamura's method as the substrate for forming a TBC system by applying a thermal barrier coating to that substrate. In any event, there is no quantitative limitation on the "smoother and flatter" diffusion aluminide bond coat surface in claim 1, only that the result obtained must be at least equivalent to "eliminating some of the grain boundary regions."

We are also not persuaded by Dr. Spitsberg's testimony that one of ordinary skill in the art would have been led away from employing Nakamura's recrystallization step in any prior art method of forming any TBC on any diffusion aluminide bond coat. Indeed, the problems associated with vertical cracks along the grain boundaries of large grains in the surface of a diffusion aluminide coating layer addressed by Nakamura's recrystallization step resulting in new fine grains in the surface of the coat, are the same problems resulting from the same vertical cracks in the same coatings observed by Dr. Spitsberg. While Dr. Spitsberg is of the opinion that such vertical cracks in a diffusion aluminide bond coat would not contribute to the TBC spallation failure mechanism resulting from thermal fatigue, because spallation takes place above the diffusion bond coat and not within the same, it seems that the information in the APA and Specification Fig. 5 indicates that spallation does result in the exposure of the diffusion aluminide bond coating because of crack propagation through the alumina

and alumina-bond coat interface. The further propagation of that crack through the diffusion aluminide bond coat would contribute to TBC system failure at least to that extent. Thus, we agree with the Examiner's determination that the problem of TBC spallation is not the same problem as crack propagation addressed by Nakamura, and thus, that one of ordinary skill in the art would use Nakamura's recrystallization step for the crack resistance properties imparted to the diffusion aluminide coat layer even though this problem may not be the underlying cause of TBC spallation.

Accordingly, based on our consideration of the totality of the record before us, we have weighed the evidence of obviousness found in the combination of the APA and Nakamura alone and as combined with the other references by the Examiner, with Appellant's countervailing evidence of and argument for nonobviousness and conclude that the claimed invention encompassed by appealed claims 1 through 20 would have been obvious as a matter of law under 35 U.S.C. § 103(a).

The Primary Examiner's decision is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv) (2007).

AFFIRMED

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Appeal 2007-0060
Application 09/524,227

HARTMAN AND HARTMAN, P.C.
552 EAST 700 NORTH
VALPARAISO, IN 46383